

A Monotonic Superclass Linearization for Dynamic Language

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July 4, 2023

1 对象的方法调用的问题

2 线性化

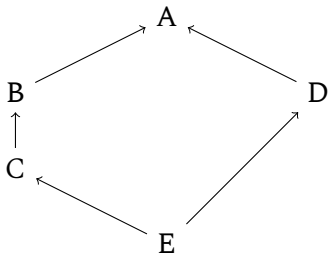
3 C3 算法

1 对象的方法调用的问题

2 线性化

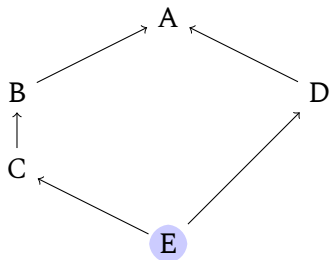
3 C3 算法

对象的方法调用的问题



```
E e = new E();  
e.method();
```

对象的方法调用的问题

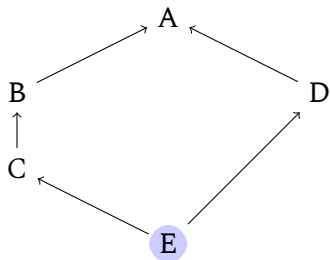


实现

重写

```
E object = new E();  
object.method();
```

对象的方法调用的问题



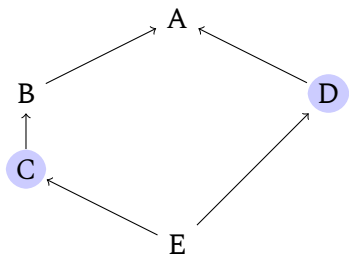
实现

重写

```
E object = new E();  
object.method();
```

调用 E 本身的方法

对象的方法调用的问题

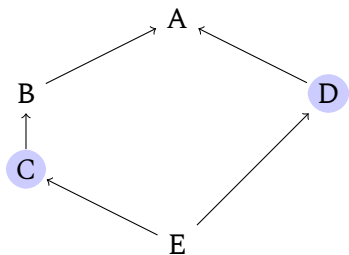


实现

重写

```
E object = new E();  
object.method();
```

对象的方法调用的问题



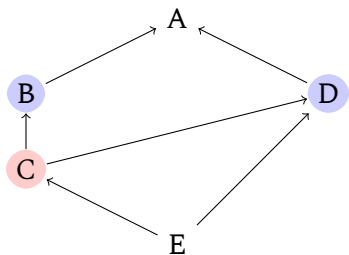
实现

重写

```
E object = new E();  
object.method();
```

调用 C 的方法

对象的方法调用的问题

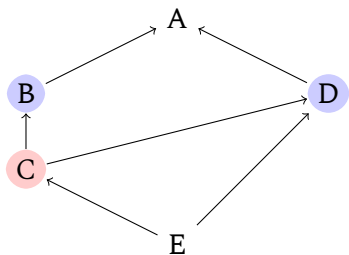


实现

重写

```
E object = new E();  
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```

对象的方法调用的问题



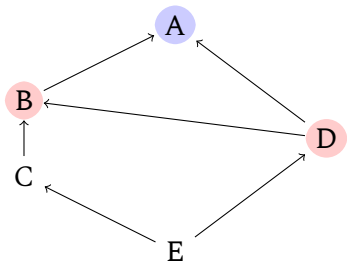
实现

重写

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E object = new E();  
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```

调用 C 的方法

对象的方法调用的问题

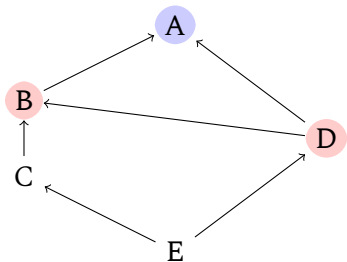


实现

重写

```
E object = new E();  
object.method();
```

对象的方法调用的问题



实现

重写

```
E object = new E();  
object.method();
```

调用 D 的方法

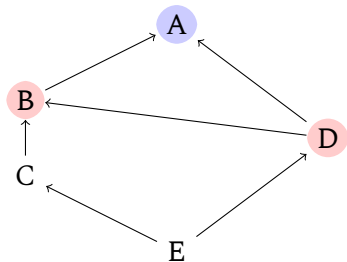
Outline

1 对象的方法调用的问题

2 线性化

3 C3 算法

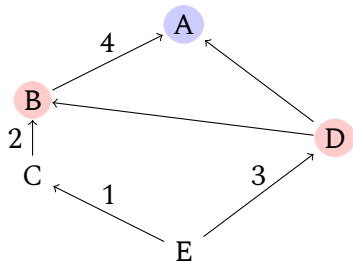
线性化



实现

重写

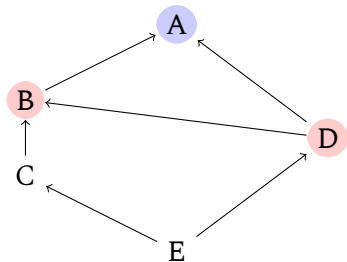
E



实现

重写

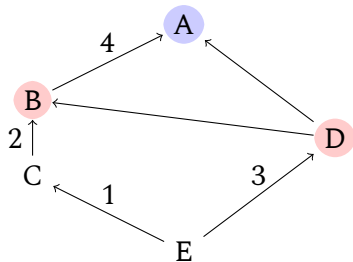
线性化



实现

重写

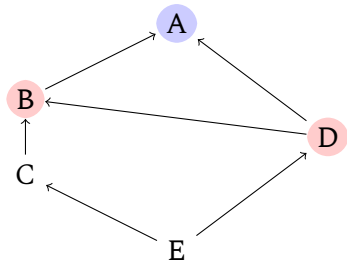
$E \rightarrow C$



实现

重写

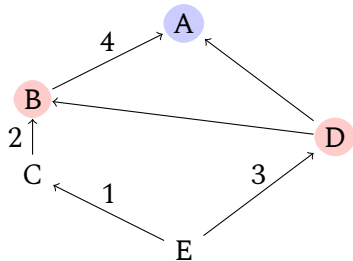
线性化



实现

重写

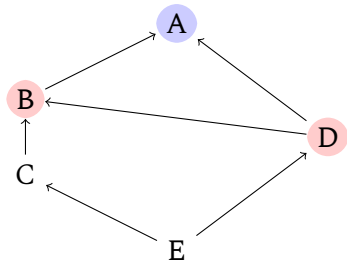
E -> C -> D



实现

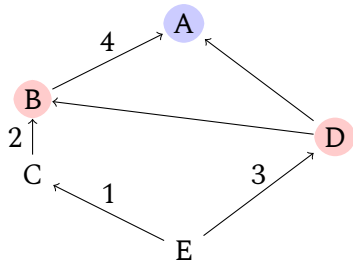
重写

线性化



实现

重写

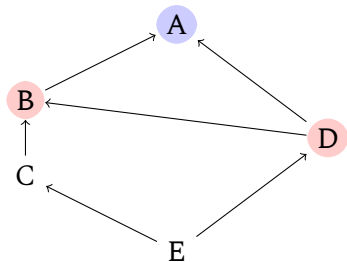


实现

重写

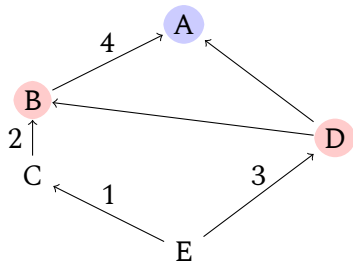
E ->C->D->B

线性化



实现

重写

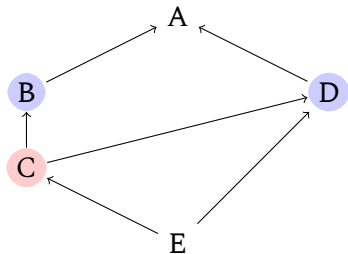


实现

重写

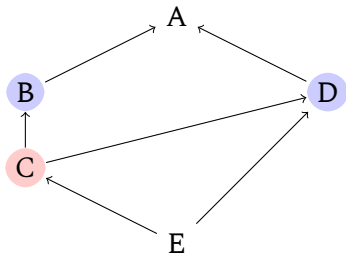
E ->C->D->B->A

线性化



实现

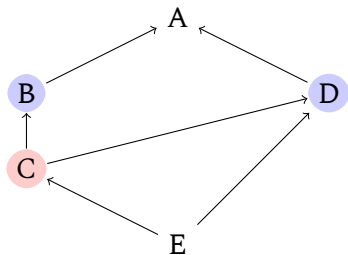
重写



实现

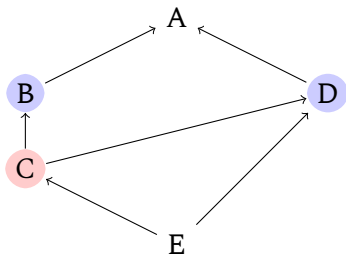
重写

E



实现

重写

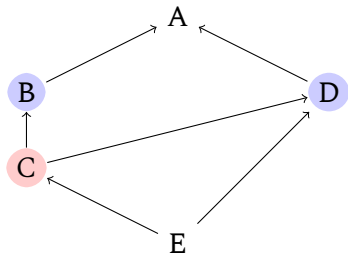


实现

重写

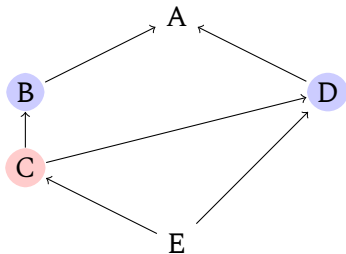
E->C

线性化



实现

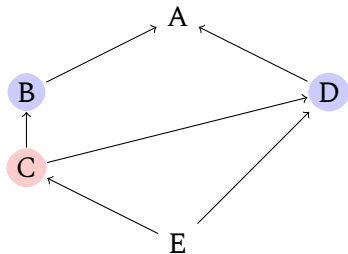
重写



实现

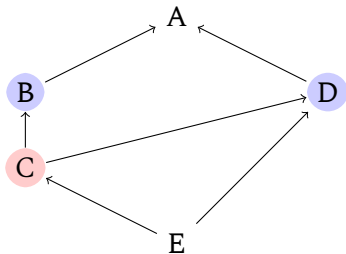
重写

E->C->B



实现

重写

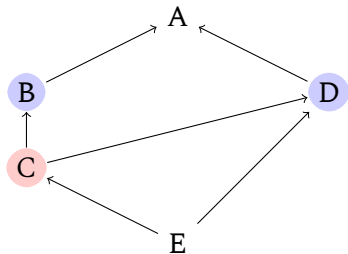


实现

重写

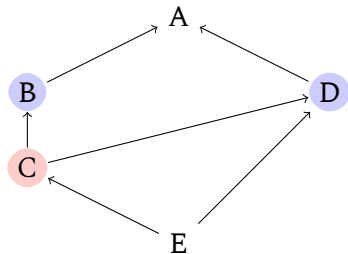
E->C->B->D

线性化



实现

重写



实现

重写

E->C->B->D->A

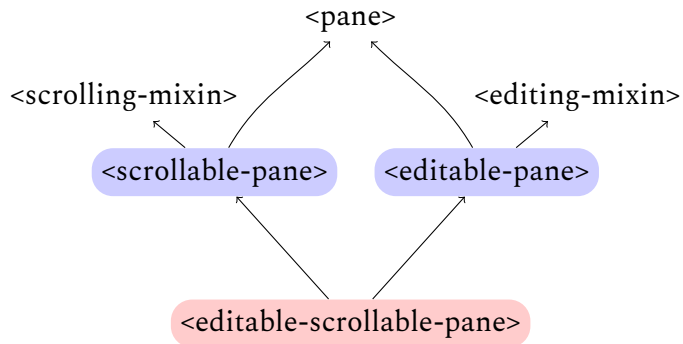
1 对象的方法调用的问题

2 线性化

3 C3 算法

- ① a consistent extended precedence graph.
- ② preservation of local precedence order.
- ③ fitting a monotonicity criterion.

preservation of local precedence order

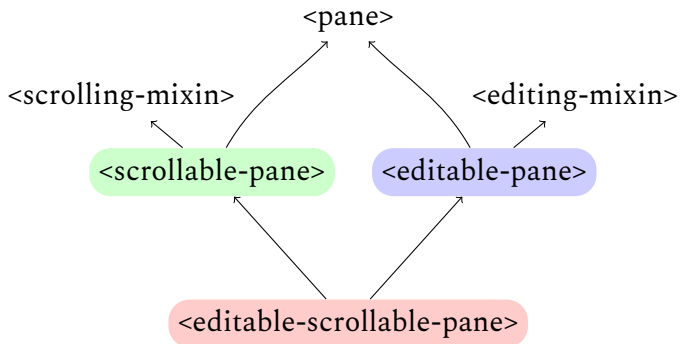


实现

重写

→ 继承

preservation of local precedence order



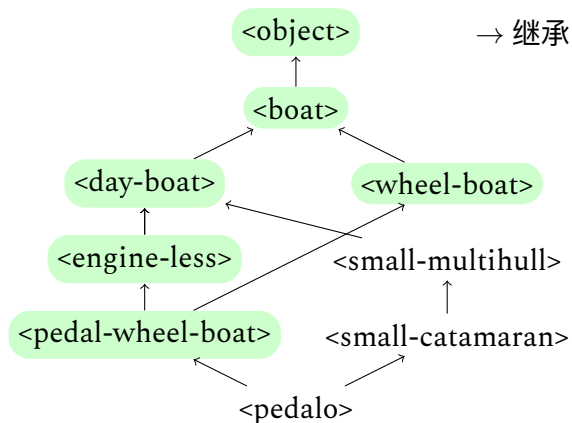
实现

重写

真正调用

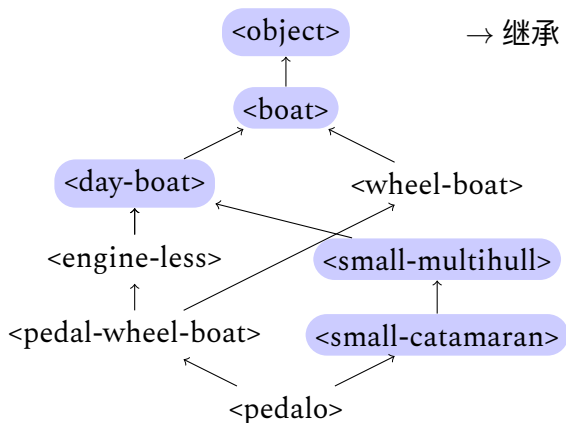
→ 继承

fitting a monotonicity criterion.



<pedal-wheel-boat>:
<pedal-wheel-boat>,
<engineless>, <day-boat>,
<wheel-boat>, <boat>,
<object>

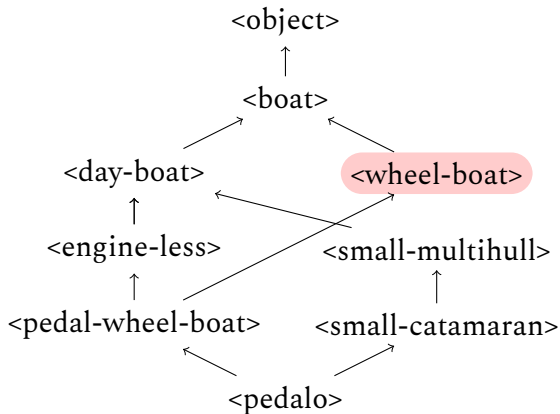
fitting a monotonicity criterion.



<pedal-wheel-boat>:
<pedal-wheel-boat>,
<engineless>, <day-boat>,
<wheel-boat>, <boat>,
<object>
<small-catamaran>:

<small-catamaran>,
<small-multihull>,
<day-boat>, <boat>,
<object>

fitting a monotonicity criterion.

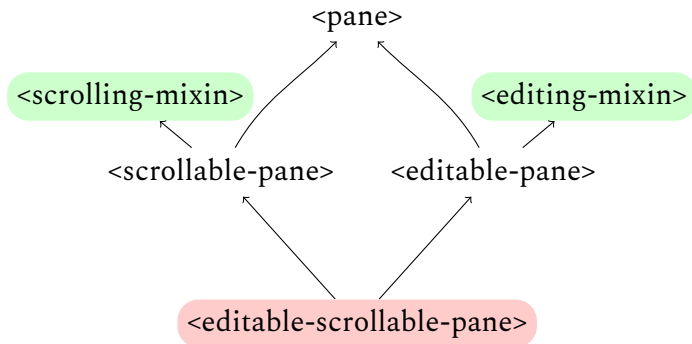


实现

违背单调性

→ 继承

a consistent extended precedence graph.

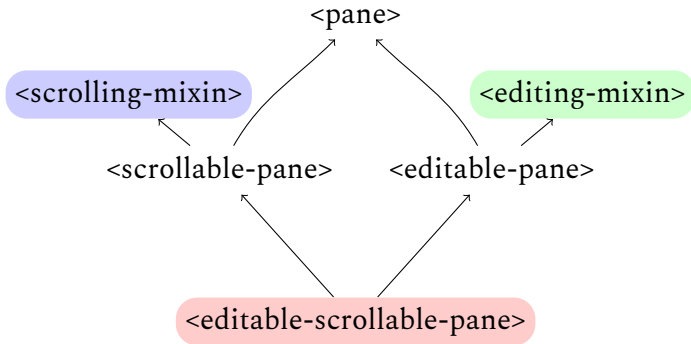


调用类

被调用类

→ 继承

a consistent extended precedence graph.



调用类

可能被调用类

真正被调用

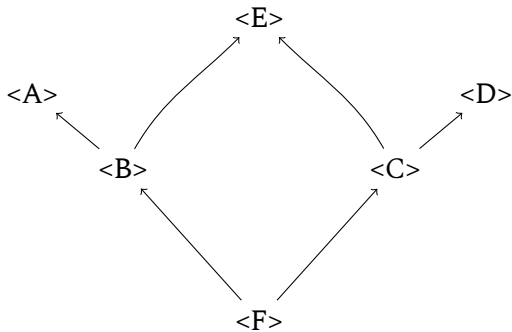
→ 继承


```
def mro(_type: type):
    bases = _type.__bases__
    lin_bases = []
    for base in bases:
        lin_bases.append(mro(base))
    lin_bases.append(list(bases))
    return [_type] + merge(lin_bases)
```

```
def merge(types):
    res = []
    seqs = types
    while True:
        seqs = [s for s in seqs if s]
        if not seqs:
            # if seqs is empty
            return res
        for seq in seqs:
            head = seq[0]
            if not [s for s in seqs if head in s[1:]]:
                break
        else:
            raise Exception('can not find mro sequence')
    res.append(head)
    for s in seqs:
        if s[0] == head:
            del s[0]
```

例子

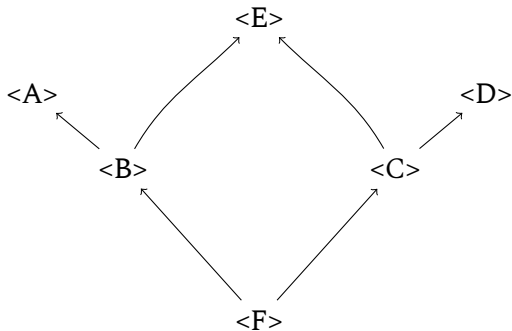
$$\text{MRO}(\mathbf{E}) = [\mathbf{E}]$$



例子

$\text{MRO}(\text{E}) = [\text{E}]$

$\text{MRO}(\text{A}) = [\text{A}]$

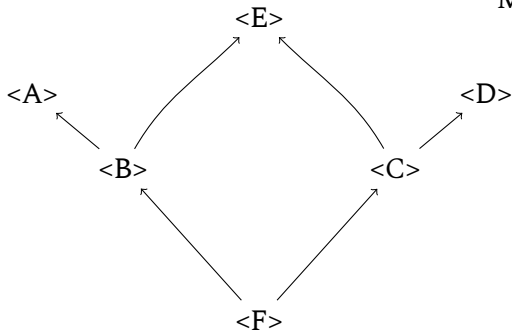


例子

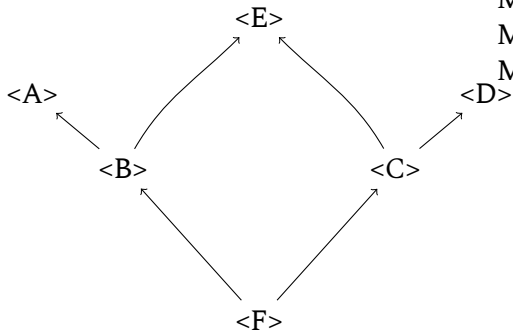
$\text{MRO}(\text{E}) = [\text{E}]$

$\text{MRO}(\text{A}) = [\text{A}]$

$\text{MRO}(\text{D}) = [\text{D}]$



例子



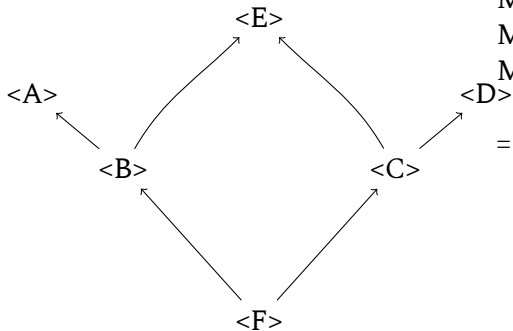
$MRO(E) = [E]$

$MRO(A) = [A]$

$MRO(D) = [D]$

$MRO(B) = [B] + \text{merge}([MRO(A),$
 $MRO(E)])$

例子



$MRO(E) = [E]$

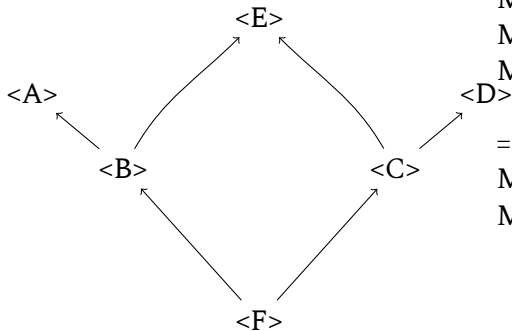
$MRO(A) = [A]$

$MRO(D) = [D]$

$MRO(B) = [B] + \text{merge}([MRO(A),$
 $MRO(E)])$

$= [B, A, E]$

例子



$\text{MRO}(\text{E}) = [\text{E}]$

$\text{MRO}(\text{A}) = [\text{A}]$

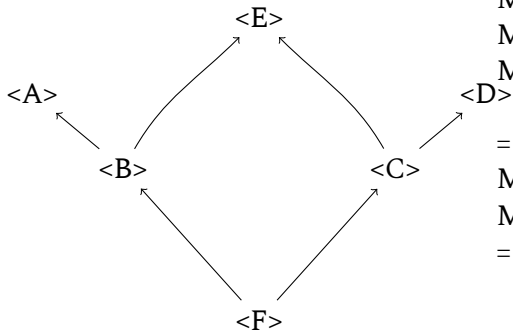
$\text{MRO}(\text{D}) = [\text{D}]$

$\text{MRO}(\text{B}) = [\text{B}] + \text{merge}([\text{MRO}(\text{A}), \text{MRO}(\text{E})])$

$= [\text{B}, \text{A}, \text{E}]$

$\text{MRO}(\text{C}) = [\text{C}] + \text{merge}([\text{MRO}(\text{E}), \text{MRO}(\text{D})])$

例子



$\text{MRO}(\text{E}) = [\text{E}]$

$\text{MRO}(\text{A}) = [\text{A}]$

$\text{MRO}(\text{D}) = [\text{D}]$

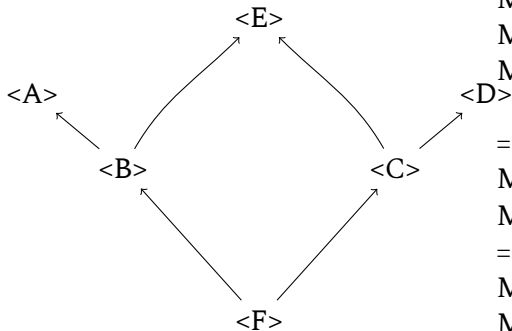
$\text{MRO}(\text{B}) = [\text{B}] + \text{merge}([\text{MRO}(\text{A}), \text{MRO}(\text{E})])$

$= [\text{B}, \text{A}, \text{E}]$

$\text{MRO}(\text{C}) = [\text{C}] + \text{merge}([\text{MRO}(\text{E}), \text{MRO}(\text{D})])$

$= [\text{C}, \text{E}, \text{D}]$

例子



$\text{MRO}(E) = [E]$

$\text{MRO}(A) = [A]$

$\text{MRO}(D) = [D]$

$\text{MRO}(B) = [B] + \text{merge}([\text{MRO}(A), \text{MRO}(E)])$

$= [B, A, E]$

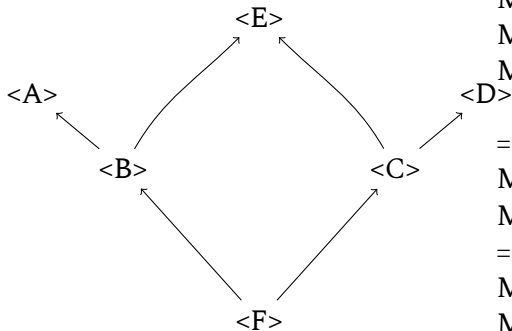
$\text{MRO}(C) = [C] + \text{merge}([\text{MRO}(E), \text{MRO}(D)])$

$= [C, E, D]$

$\text{MRO}(F) = [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)])$

$= [F] + \text{merge}([[B, A, E], [C, E, D]])$

例子



$MRO(E) = [E]$

$MRO(A) = [A]$

$MRO(D) = [D]$

$MRO(B) = [B] + \text{merge}([MRO(A),$
 $MRO(E)])$

$= [B, A, E]$

$MRO(C) = [C] + \text{merge}([MRO(E),$
 $MRO(D)])$

$= [C, E, D]$

$MRO(F) = [F] + \text{merge}([MRO(B),$
 $MRO(C)])$

$= [F] + \text{merge}([B, A, E], [C, E, D])$

$= [F, B, A, C, E, D]$

$$\begin{aligned} \text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \end{aligned}$$

$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D])\end{aligned}$$

$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D])\end{aligned}$$

$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D])\end{aligned}$$

$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([\text{B}, A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D])\end{aligned}$$

$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D])\end{aligned}$$

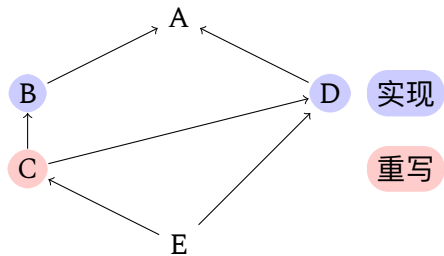
$$\begin{aligned}\text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D])\end{aligned}$$

$$\begin{aligned} \text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([[B, A, E], [C, E, D]]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D]) \\ &= [F, B, A, C] + \text{merge}([], [D]) \end{aligned}$$

$$\begin{aligned} \text{MRO}(F) &= [F] + \text{merge}([\text{MRO}(B), \text{MRO}(C)]) \\ &= [F] + \text{merge}([\text{B}, A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B] + \text{merge}([A, E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A] + \text{merge}([E], [C, E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D]) \\ &= [F, B, A, C] + \text{merge}([E], [E, D]) \\ &= [F, B, A, C] + \text{merge}([], [D]) \\ &= [F, B, A, C, E, D] \end{aligned}$$

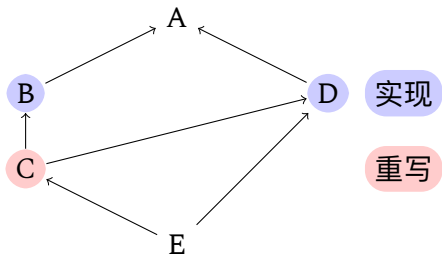
例子

$$\text{MRO}(A) = [A]$$

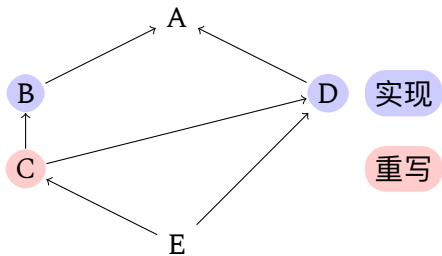


例子

$\text{MRO}(A) = [A]$
 $\text{MRO}(B) = [B]$



例子

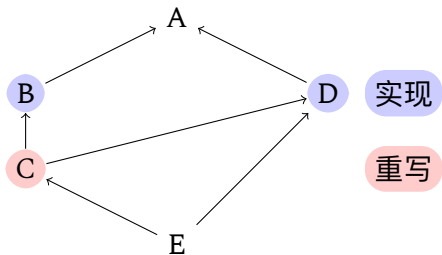


$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

$\text{MRO}(D) = [D]$

例子



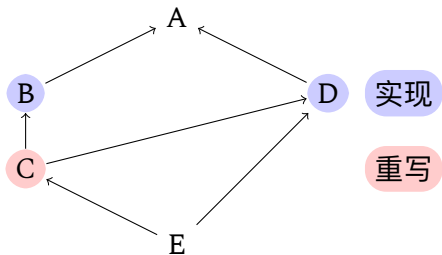
$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

$\text{MRO}(D) = [D]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

例子



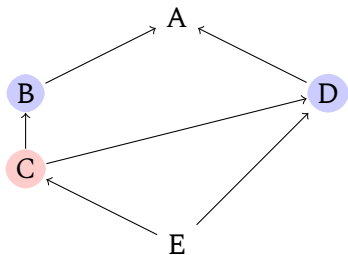
$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

$\text{MRO}(D) = [D]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$
 $= [C] + \text{merge}([B, A], [D, A])$

例子



实现

重写

$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

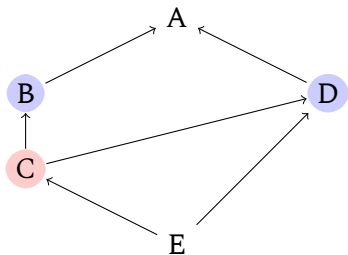
$\text{MRO}(D) = [D]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

$= [C] + \text{merge}([B, A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

例子



实现

重写

$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

$\text{MRO}(D) = [D]$

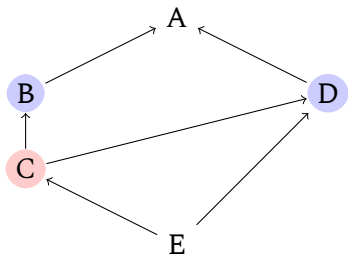
$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

$= [C] + \text{merge}([B, A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

例子



实现

重写

$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B]$

$\text{MRO}(D) = [D]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

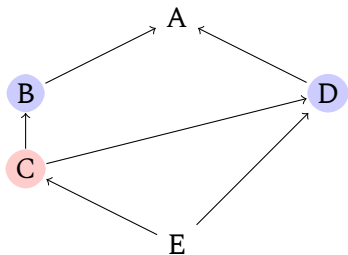
$= [C] + \text{merge}([B, A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

$= [C, B, D] + \text{merge}([A], [A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B]$

$MRO(D) = [D]$

$MRO(C) = [C] + \text{merge}(MRO(B), MRO(D))$

$= [C] + \text{merge}([B, A], [D, A])$

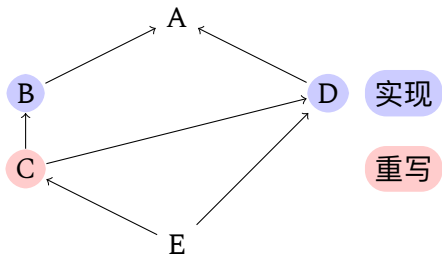
$= [C, B] + \text{merge}([A], [D, A])$

$= [C, B] + \text{merge}([A], [D, A])$

$= [C, B, D] + \text{merge}([A], [A])$

$= [C, B, D, A]$

例子

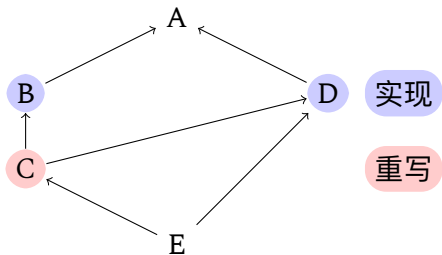


$\text{MRO}(C) = [C, B, D, A]$

$\text{MRO}(D) = [D, A]$

$\text{MRO}(E) = [E] + \text{merge}(\text{MRO}(C), \text{MRO}(D))$

例子



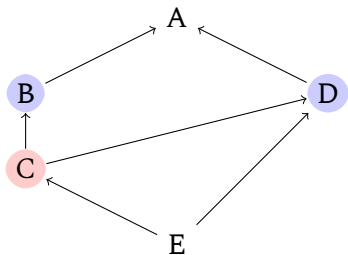
$\text{MRO}(C) = [C, B, D, A]$

$\text{MRO}(D) = [D, A]$

$\text{MRO}(E) = [E] + \text{merge}(\text{MRO}(C), \text{MRO}(D))$

$\text{MRO}(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

例子



实现

重写

$MRO(C) = [C, B, D, A]$

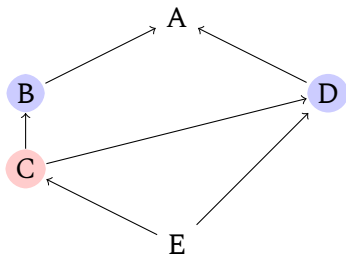
$MRO(D) = [D, A]$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

例子



实现

重写

$MRO(C) = [C, B, D, A]$

$MRO(D) = [D, A]$

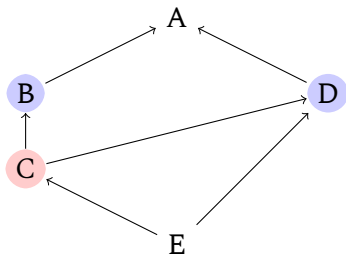
$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

例子



实现

重写

$MRO(C) = [C, B, D, A]$

$MRO(D) = [D, A]$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

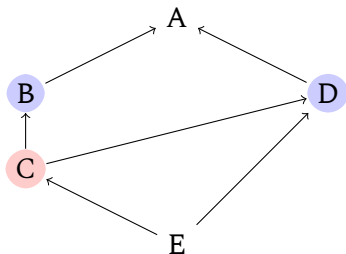
$MRO(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C, B] + \text{merge}([D, A], [D, A])$

例子



实现

重写

$MRO(C) = [C, B, D, A]$

$MRO(D) = [D, A]$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

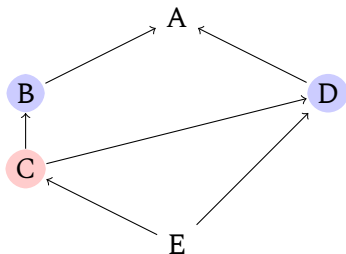
$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C, B] + \text{merge}([D, A], [D, A])$

$MRO(E) = [E, C, B, D] + \text{merge}([A], [A])$

例子



实现

重写

$MRO(C) = [C, B, D, A]$

$MRO(D) = [D, A]$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

$MRO(E) = [E, C] + \text{merge}([B, D, A], [D, A])$

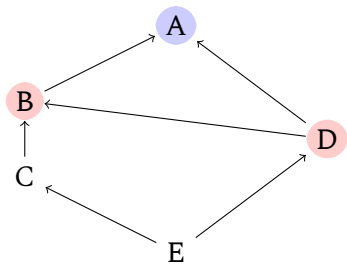
$MRO(E) = [E, C, B] + \text{merge}([D, A], [D, A])$

$MRO(E) = [E, C, B, D] + \text{merge}([A], [A])$

$MRO(E) = [E, C, B, D, A]$

例子

$\text{MRO}(A) = [A]$

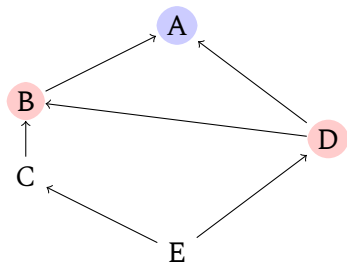


实现

重写

例子

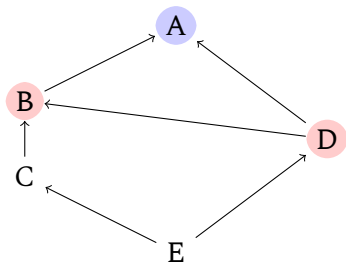
$\text{MRO}(A) = [A]$
 $\text{MRO}(B) = [B, A]$



实现

重写

例子



$\text{MRO}(A) = [A]$

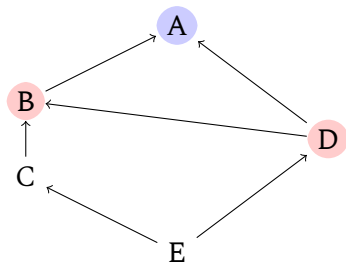
$\text{MRO}(B) = [B, A]$

$\text{MRO}(D) = [D, A]$

实现

重写

例子



$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B, A]$

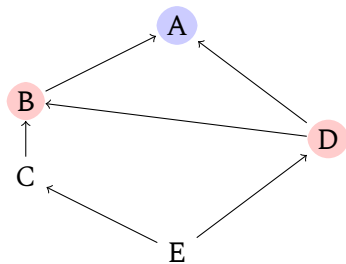
$\text{MRO}(D) = [D, A]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B))$

实现

重写

例子



实现

重写

$\text{MRO}(A) = [A]$

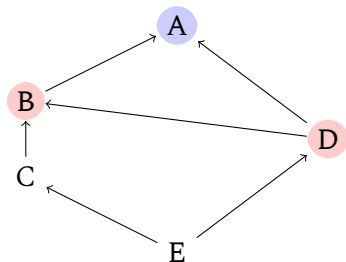
$\text{MRO}(B) = [B, A]$

$\text{MRO}(D) = [D, A]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B))$

$\text{MRO}(C) = [C] + [B, A]$

例子



$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

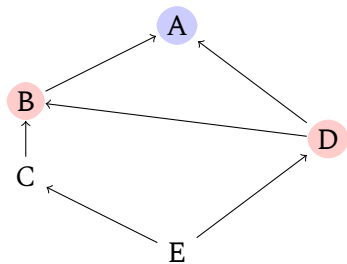
$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

实现

重写

例子



实现

重写

$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B, A]$

$\text{MRO}(D) = [D, A]$

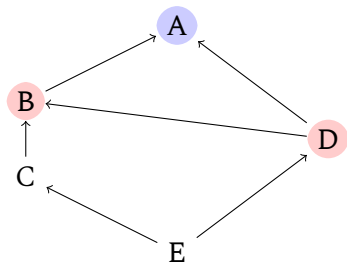
$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B))$

$\text{MRO}(C) = [C] + [B, A]$

$\text{MRO}(C) = [C, B, A]$

$\text{MRO}(D) = [D] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

例子



$\text{MRO}(A) = [A]$

$\text{MRO}(B) = [B, A]$

$\text{MRO}(D) = [D, A]$

$\text{MRO}(C) = [C] + \text{merge}(\text{MRO}(B))$

$\text{MRO}(C) = [C] + [B, A]$

$\text{MRO}(C) = [C, B, A]$

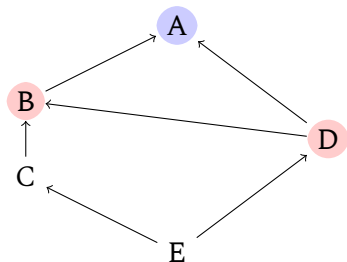
$\text{MRO}(D) = [D] + \text{merge}(\text{MRO}(B), \text{MRO}(D))$

$\text{MRO}(E) = [E] + \text{merge}(\text{MRO}(C), \text{MRO}(D))$

实现

重写

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

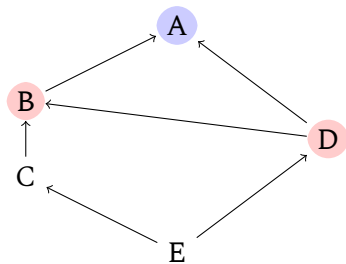
$MRO(C) = [C, B, A]$

$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

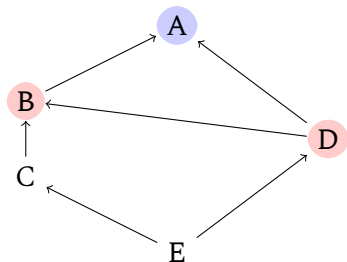
$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

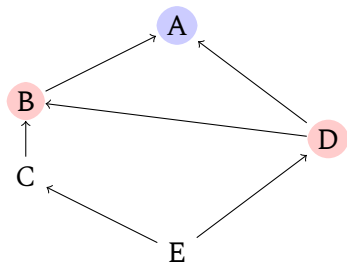
$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

$MRO(E) = [E] + \text{merge}([\textcolor{red}{C}, B, A], [D, B, A])$

$MRO(E) = [E, C] + \text{merge}([\textcolor{blue}{B}, A], [\textcolor{red}{D}, B, A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

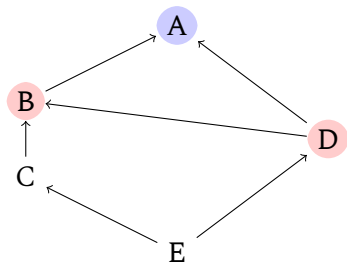
$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

$MRO(E) = [E] + \text{merge}([\textcolor{red}{C}, B, A], [D, B, A])$

$MRO(E) = [E, C] + \text{merge}([\textcolor{blue}{B}, A], [\textcolor{red}{D}, B, A])$

$MRO(E) = [E, C, D] + \text{merge}([\textcolor{red}{B}, A], [B, A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

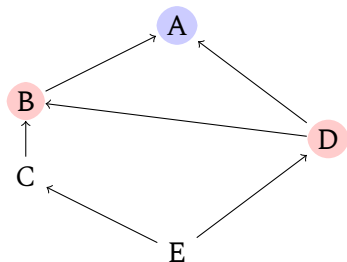
$MRO(E) = [E] + \text{merge}([\text{C}], [B, A], [D, B, A])$

$MRO(E) = [E, C] + \text{merge}([B, A], [D, B, A])$

$MRO(E) = [E, C, D] + \text{merge}([B, A], [B, A])$

$MRO(E) = [E, C, D, B] + \text{merge}([A], [A])$

例子



实现

重写

$MRO(A) = [A]$

$MRO(B) = [B, A]$

$MRO(D) = [D, A]$

$MRO(C) = [C] + \text{merge}(MRO(B))$

$MRO(C) = [C] + [B, A]$

$MRO(C) = [C, B, A]$

$MRO(D) = [D] + \text{merge}(MRO(B), MRO(D))$

$MRO(E) = [E] + \text{merge}(MRO(C), MRO(D))$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

$MRO(E) = [E] + \text{merge}([C, B, A], [D, B, A])$

$MRO(E) = [E, C] + \text{merge}([B, A], [D, B, A])$

$MRO(E) = [E, C, D] + \text{merge}([B, A], [B, A])$

$MRO(E) = [E, C, D, B] + \text{merge}([A], [A])$

$MRO(E) = [E, C, D, B, A]$